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Key terms: burden of disease; Denmark; depression; excess fraction; industrial inequality; mood disorder; work-relatedness

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Original article

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Work-relatedness of mood disorders in Denmark

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Objective To determine the work-relatedness of mood disorders.

Methods From 2001–2005, we followed up all economically active people in Denmark, aged 20–59 years as of January 2001, for hospital contact due to mood disorders. We calculated gender-stratified standardized incidence ratios (SIR) by industry. Using the distribution of the SIR values as input, we used a Monte Carlo simulation to estimate what proportion of the mood disorder cases could be regarded as work-related and denoted them as excess fractions.

Results In total, we observed 10 731 cases of mood disorder among the women and 8305 among the men. There were four industries among women and 13 among men that showed elevated SIR with confidence intervals not including unity. The excess fractions without social group adjustment were 0.248 [95% confidence interval (95% CI) 0.173–0.325] for the women and 0.363 (95% CI 0.294–0.433) for the men. The respective fractions with adjustment for social group were 0.233 (95% CI 0.162–0.303) and 0.361 (95% CI 0.293–0.430).

Conclusion A substantial proportion of mood disorders among working people can be regarded as work-related. Hence, the workplace is an interesting arena for primary interventions.

Key terms burden of disease; depression; excess fraction; industrial inequality.

Mood disorders, which include unipolar (major) depression and bipolar disorders, have a relatively high prevalence among economically active people. A recent American study reported that 7.0% of full-time workers aged 18–64 years experienced a major depressive episode in the past year (1). A review of European studies identified 17 studies on major depression with a mean prevalence of 6.9% (range 3.1–10.1) and six studies on bipolar disorders with a mean prevalence of 0.9% (range 0.2 –1.1) (2). According to recent reports, depression is the leading cause of disability among adults (3, 4). In the working population, it is a major source of sickness-absence (5, 6) and early retirement (7, 8).

Studies have indicated that the risk of mood disorder among economically active people to some extent depends on the work-environment. The following variables have been suggested to be associated with depression: job dissatisfaction (9), long working hours (10–13), job strain (13–20), high job demands (21–24), low job control (19–26), job insecurity (18, 22, 26), low social support at work (19, 21, 22, 24, 26, 27), effort-reward imbalance (20, 28), workplace bullying (29), conflicting demands (23), and organizational injustice (15). Work should, however, not be regarded only as a negative factor in the development of mood disorders. Work characteristics might also play a beneficial role by providing a social environment and a stable financial situation which might be relevant factors in the prevention of mood disorders.

It is not well-known, to what extent mood disorders can be attributed to the work environment. To our knowledge only two studies have attempted to estimate such a proportion. Nurminen & Karjalainen (30) estimated that 14.6% of deaths related to depressive episodes among men and 9.8% among women were attributable to work environment exposures. LaMontagne et al (14) estimated that 13.2% (95% CI 1.1–28.1) of depression cases among men and 17.2% (95% CI 1.5–34.9) among women were attributable to job strain (14). A limitation of the study of Nurminen & Karjalainen was that it only examined deaths. Since we are dealing with mental disorders, morbidity estimates

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would have been more useful. The width of the confidence intervals was a drawback of the LaMontagne et al study.

Our study attempted to answer the question: "What proportion of the cases of mood disorders among economically active people in Denmark can be attributed to a non-optimum work environment?" The study encompassed more than 2 000 000 people and almost 20 000 cases of mood disorder morbidity.

Material and methods

Data source

Our study used information from the Danish Occupational Psychiatric Register (OPR), a database comprising the linked records of three national registers – the Central Person Register, the Psychiatric Central Register, and the Employment Classification Module. Currently, the OPR includes every person who was economically active and an inhabitant of Denmark at any point in time between 1995 and 2005.

The Danish Psychiatric Central Register contains information dating from the 19th century; data have been collected systematically since 1938. Since 1969, data on psychiatric admissions were computerized and include all admissions to psychiatric hospitals and psychiatric wards in general hospitals in Denmark, the Faroe Islands, and Greenland. As of 1994, all diagnoses have been coded according to the tenth version of the International Classification of Diseases (ICD-10) (31). Since 1 January 1995, information on all psychiatric outpatient contacts has been included. The Register has many advantages including close collaboration with the reporting hospitals and departments, as well as its organization within the psychiatric epidemiological and social psychiatric research unit of the Department of Psychiatric Demography (32).

The central person register contains information on gender, addresses, and dates of birth, death and migrations for every person who is or has been an inhabitant of Denmark sometime between 1968 and the present time. Age and gender are part of the personal identification number, which is recorded practically without errors (33).

Since 1975, every adult person in Denmark has been classified annually according to industry, occupation, and socio-economic status in the Employment Classification Module (34). The industries in the Module are coded in accordance with the 1993 Danish Industrial Classification of All Economic Activities (35), which is a national version of the European Industrial Classification of All Economic Activities.

The subjects

To be included in our study, subjects had to meet three general criteria. At baseline (1 January 2001), they had to be inhabitants of Denmark, aged between 20–59 years according to the Central Person Register, and economically active according to the European Classification Module. Subjects who had received psychiatric hospital treatment for mood disorders in the three years prior to baseline (1 January 1998–31 December 2000), were excluded from the analysis. The study included 1 276 687 men and 1 136 753 women, with 6 357 541 and 5 652 992 person years at risk, respectively.

End point and follow-up

We followed up the study subjects for their first hospital contact with a mood disorder (ICD-10 = F30–F39) as the principal diagnosis in the time period 2001–2005. There are three types of hospital contacts, namely in-patient treatment, out-patient treatment, and emergency ward visits. The mood disorders include the following sub-diagnoses: (i) F30 manic episode; (ii) F31 bipolar affective disorder; (iii) F32 depressive episode; (iv) F33 recurrent depressive disorder; (v) F34 persistent mood (affective) disorder; (vi) F38 other mood (affective) disorder; and (v) F39 unspecified mood (affective) disorder.

Preliminary calculations

We used dates of deaths, emigrations, and hospital contacts to calculate person years at risk for each individual. The analysis was stratified by gender. We used indirect standardization to adjust for age category (20–24, 25–29 … 55–59 years), with all economically active men and women in the total population of Denmark as standard population. We calculated standardized incidence ratios (SIR) by industry and used the official industrial classification of the National Research Centre of the Working Environment, which contains 57 different industrial groups.

Estimation of the excess fraction

The term "excess fraction" refers to the proportion of the cases of mood disorder that would *not* have occurred if the concerned morbidity rate in each industry had been as low as that in the industry associated with the lowest risk. Mathematically, this is expressed as:

$$EF = \frac{\sum_i p_i(RR_i - 1)}{1 + \sum_i p_i(RR_i - 1)}$$

where p_i is the proportion of the expected cases that pertains to industry i under the assumption of equality and RR_i is the unobservable true risk ratio between industry i and the industry with the lowest risk.

Since the true risk ratios are unknown, the aforementioned equation cannot be solved explicitly. Moreover, it follows from the statistical distribution function for order statistics (36) that the range of the estimated risks are likely to be wider than the range of the true risks, and that the lowest estimated risk is likely to be lower than the lowest true risk. Observed differences in risk estimates reflect, in other words, the combined effect of random and systematic differences. Hence, if we were to replace the true risk ratios with observed ones (obtained by comparing the rate in each industry with the lowest observed rate) we would obtain a severely biased excess fraction estimate. We can solve this problem by estimating the excess fraction implicitly through a Monte Carlo simulation. The purpose of the simulation is to find and deduct the part of the inequalities that are the result of solely random fluctuations and thereby enable an estimate of the actual inequalities in the risk of contracting the outcome in question.

In our study, we used a Monte Carlo simulation to find the excess fraction that corresponds with the observed variation between the industries. The general principles of how to use a computer-aided Monte Carlo simulation to estimate statistical parameters are well described, for example, by Morgan (37) and Ross (38). We performed the simulations with the statistical analysis software SAS version 9.1 (SAS Institute, Cary, NC, USA) on the basis of the two following assumptions: (i) the number of mood disorder cases in each industry follows a Poisson distribution and (ii) the industries' true risk ratios increase geometrically with their rank order.

The observed variation was measured with Pearson's chi-square (39). All details on this particular estimation procedure are given by Feveile et al (40).

A part of the excess fraction might be due to industrial differences in the composition of social status groups. In order to explore this, we calculated the excess fraction both with and without standardization for five social classes: (i) legislators, senior officials and managers; (ii) professionals; (iii) technicians and associate professionals; (iv) employees in a work that requires skills at a basic level; and (v) employees in elementary occupations) according to the official classification system used by Statistics Denmark.

Description of the standardization procedure

Among men, the age and social group standardised incidence ratio (SIR) for industry *l* was obtained by the formula:

$$SIR_{men,l} = \frac{\sum_i \sum_j x_{men,i,j,l}}{\sum_i \sum_j \left(\frac{\sum_k x_{men,i,j,k}}{\sum_k Pyrs_{men,i,j,k}} \right) Pyrs_{men,i,j,l}}$$

Among men, the age standardised incidence ratio (SIR) for industry l was obtained by the formula:

$$SIR_{men,l} = \frac{\sum_i \sum_j x_{men,i,j,l}}{\sum_j \left(\frac{\sum_i \sum_k x_{men,i,j,k}}{\sum_i \sum_k Pyrs_{men,i,j,k}} \right) \left(\sum_i Pyrs_{men,i,j,l} \right)}$$

In both these formulas, let $x_{men,i,j,k}$ be the observed number of cases among the men who belong to social group *i*, age group *j* and industry *k*.

Let $Pyrs_{men,i,j,k}$ be the observed person years of risk among the men who belong to social group *i*, age group *j* and industry *k*.

The procedure used to estimate SIR values among the women is obtained by substituting "men" with "women" in the above text.

Results

In total, we observed 10 731 cases of mood disorder among the women and 8305 among the men. Among the women, there were 190 cases per 100 000 person years. The respective number among the men was 131. The diagnosis distribution is given by gender in table 1. Table 2 shows a complete list of SIR values and 95% confidence intervals by industry for women and men, respectively. There were four industries among women that showed elevated SIR values with confidence intervals not including unity (ie, finishing; cleaning; nursing homes/homecare; and child care). All four industries also showed elevated SIR values among men. In addition, among men, there were nine other industries showing elevated SIR values with confidence intervals that did not include unity. Among both the men and women, there were five industries that had low SIR values with confidence intervals not including unity (ie, earth, concrete and pavement contractors; finance and public administration; private office and administration; car dealerships; and telecommunication).

Without adjusting for social group, the excess fractions for mood disorders were 0.248 (95% CI 0.173–0.325) among the women and 0.363 (95% CI 0.294–0.433) among the men. The respective fractions when adjusting for social group were 0.233 (95% CI 0.162–0.303) and 0.361 (95% CI 0.293–0.430). Although the results were nearly the same with and without adjustment for social group, this does not necessarily indicate that the risk for mood disorders was independent of social group. For example, men in the social group "employees in elementary occupations" had a 38% higher risk of mood disorders than men in the "professionals" social group, while women employed in elementary

Table 1. Distribution of mood-disorders among men and women treated at Danish psychiatric hospitals, 2001–2005.

Diagnosis (ICD-10)	Men		Women	
	Frequency	%	Frequency	%
F30 Manic episode	198	2.38	140	1.3
F31 Bipolar affective disorder	637	7.67	634	5.91
F32 Depressive episode	5322	64.08	6714	62.57
F33 Recurrent depressive disorder	1878	22.61	2853	26.59
F34 Persistent mood (affective) disorders	177	2.13	255	2.38
F38 Other mood (affective) disorders	46	0.55	63	0.59
F39 Unspecified mood (affective) disorder	47	0.57	72	0.67

Table 2. Industrial standardized incidence ratios (SIR) for affective disorders (ICD-10 = F30-F39) with 95% confidence interval (95% CI) among Danish men and women 2001–2005.

Industry	Men			Women		
	Cases (N)	SIR	95% CI	Cases (N)	SIR	95% CI
010 Metal- & steelworks, & foundries	36	0.95	0.66–1.31	17	1.21	0.71–1.94
020 Manufacture of transport equipment	58	0.80	0.61–1.04	16	0.68	0.39–1.10
030 Shipyards	25	0.77	0.50–1.13	2	0.67	0.08–2.42
040 Electricity & heat supply	32	0.61	0.42–0.86	11	0.50	0.25–0.89
050 Iron & metal industry	232	0.98	0.87–1.12	109	1.01	0.84–1.22
060 Engineering industry	302	0.86	0.77–0.96	107	0.91	0.75–1.10
070 Electricity & electronics industry	122	0.94	0.78–1.12	142	1.00	0.85–1.18
080 Car industry	115	0.87	0.73–1.05	18	0.61	0.36–0.97
090 Earth, concrete & pavement contractors	278	0.89	0.79–1.00	22	0.57	0.36–0.87
100 Bricklayer, joiner, & carpentry work	253	0.93	0.82–1.05	17	0.85	0.49–1.36
110 Finishing	109	1.22	1.01–1.48	56	1.45	1.10–1.88
120 Insulation & installation businesses	241	0.92	0.81–1.04	41	0.99	0.71–1.35
130 Printing works & publishing	129	1.03	0.87–1.23	111	0.89	0.74–1.07
140 Paper, cardboard & bookbinding industries	50	1.23	0.92–1.63	24	0.96	0.61–1.42
150 Wholesale trade	557	0.80	0.74–0.87	365	0.79	0.71–0.87
160 Transport of goods	477	0.98	0.89–1.07	197	1.01	0.88–1.17
170 Transport of passengers	298	1.16	1.04–1.30	133	1.03	0.87–1.22
180 Fire service, lighthouse & salvage corps	31	0.68	0.46–0.96	11	1.00	0.50–1.78
190 Textile, clothing, & leather industry	34	0.83	0.58–1.17	70	0.94	0.73–1.18
200 Manufacture of wood & wood products	229	1.28	1.12–1.45	81	0.85	0.67–1.05
210 Mineral, oil, rubber & plastic products	88	0.86	0.69–1.06	63	0.82	0.63–1.05
220 Stone-works, pottery, & glass industry	98	1.20	0.98–1.47	27	0.80	0.52–1.16
230 Medical equipment/ toys/cameras, etc	41	0.82	0.59–1.12	60	0.81	0.62–1.05
240 Manufacture of industrial chemicals	61	0.93	0.71–1.19	33	0.59	0.41–0.83
250 Heavy raw material & semi-manufacture	25	0.73	0.47–1.07	8	0.98	0.42–1.93
260 Pharmaceutical industry	25	0.78	0.51–1.16	48	0.78	0.57–1.03
271 Office & administration (transport & wholesale)	63	0.84	0.64–1.07	48	0.84	0.62–1.11
272 Office & administration (service)	103	1.27	1.04–1.54	41	0.95	0.68–1.29
273 Finance/ Public office & administration	339	0.84	0.75–0.93	725	0.81	0.76–0.88
274 Private office & administration	610	0.86	0.79–0.93	712	0.85	0.79–0.91
281 Car dealerships	91	0.79	0.64–0.97	13	0.58	0.31–0.98
282 Garage	14	0.65	0.35–1.09	37	0.99	0.70–1.36
283 Shops	188	0.98	0.85–1.13	404	0.92	0.83–1.01
290 Supermarkets, department stores, etc	154	0.79	0.68–0.93	336	0.90	0.81–1.01
300 Sewers, water & gas supply	23	0.87	0.55–1.31	7	0.78	0.31–1.60
310 Personal care & other services	36	0.95	0.66–1.31	132	0.95	0.80–1.13
320 Cleaning, laundries, & dry cleaners	148	1.30	1.11–1.53	369	1.43	1.29–1.58
330 Telecommunication	60	0.73	0.56–0.94	67	0.76	0.59–0.97
340 Surveillance, armed forces, police, etc	188	0.70	0.60–0.80	84	0.83	0.66–1.03
350 Hotels & restaurants	210	1.31	1.15–1.50	339	1.08	0.97–1.21
361 Photographers/film & video production	21	1.03	0.64–1.57	27	1.42	0.93–2.06
362 Entertainment, culture & sport	116	1.06	0.88–1.27	120	0.91	0.76–1.09
363 Libraries & archives	17	1.42	0.83–2.27	42	0.90	0.65–1.21
370 Slaughterhouse industry	112	1.24	1.03–1.50	38	0.91	0.64–1.24
380 Poultry slaughtering & fish products	30	1.01	0.68–1.45	47	0.84	0.62–1.12
390 Beverage industry	53	0.92	0.69–1.21	25	0.68	0.44–1.01
400 Manufacture of bread, chocolate, tobacco, etc	80	1.21	0.96–1.51	103	1.00	0.82–1.21
410 Manufacture of dairy products	42	0.92	0.66–1.24	39	1.03	0.73–1.40
420 Agriculture	204	0.75	0.66–0.86	96	1.00	0.81–1.22
430 Horticulture & forestry	75	1.09	0.86–1.37	53	0.88	0.66–1.15
440 Hospitals	164	1.42	1.22–1.65	741	0.98	0.91–1.05
450 Nursing homes, home care, etc	263	2.11	1.87–2.38	1700	1.29	1.23–1.35
460 Child care, etc	285	1.91	1.70–2.14	1293	1.11	1.05–1.17
471 General practitioners, dentists, etc	46	1.47	1.07–1.95	160	0.95	0.81–1.11
472 Healthcare (not classified elsewhere)	81	1.28	1.02–1.59	209	0.95	0.83–1.08
480 Education & research	516	1.10	1.01–1.20	934	0.95	0.89–1.02
490 Fishing	27	0.99	0.65–1.43	1	1.46	0.04–8.12

occupations had a 49% increased risk compared with female professionals. The overall inequalities between industries (as measured by the excess fraction) were, however, unaffected by the social group adjustment.

We also estimated the excess fraction for the subdiagnosis depressive episodes (ICD-10 = F32) which should be a more homogenous category. For this diagnosis, the excess fractions without social group adjustment were 0.237 (95% CI 0.157–0.313) among the women and 0.330 (95% CI 0.258–0.400) among the men. Adjusting for social group, the respective fractions were 0.211 (95% CI 0.137–0.280) and 0.322 (95% CI 0.253–0.389).

Discussion

We found substantial differences among industries in the risk of contracting a mood disorder, both for men and women. The excess fractions suggest that a considerable proportion of mood disorders among economically active people would not have occurred if the working environment in each industry were as favorable as that of the industry with the lowest risk.

Of the four industries among women and the 13 industries among men with elevated SIR, many belonged to the human services profession (eg, healthcare, child care, and education). This is in line with findings from an earlier study by Wieclaw et al (41, 42) that showed an increased risk for hospitalization for mood-, stress- and anxiety-related disorders among human services professionals. In their study, Wieclaw et al had also used information from the Danish Psychiatric Central Register. However, in contrast to our study, they did not conduct a prospective study, but rather a case-control analysis. Interestingly, one of their findings was that the association between working in the human services profession and the risk of psychological ill-health was stronger in men than women (42). We found a similar result in our study (ie, working in nursing homes and home care had a SIR of 1.29 and 2.11 for women and men, respectively; and working in child care had an SIR of 1.11 and 1.91 for women and men, respectively).

Strengths and limitations

The fact that we used a prospective design and a large population was a strength of our study. Another strength was that we were able to identify and exclude people who had received treatment for mood disorders in the three years prior to the baseline period. Hence, we did not include any prevalent cases in the analyses. However, we cannot rule out selection into industries, due to individual pre-dispositions (eg, psychological vulnerability), as a contributing factor in our findings. A psychologically fragile person, might for example avoid work in industries associated with high psychological demands such as hospitals or emergency services. Psychologically strong persons, on the other hand, might actively seek and thrive in psychologically challenging work environments.

A limitation of our method is that we did not actually measure the quality of working life but just concentrated on differences between 57 industries. Another drawback was that the optimum work environment might not exist in any industry. Thus, instead of comparisons with the best *possible* work environment we used the best *existing* work environment. The excess fractions could therefore be considered somewhat underestimated. However, since theoretical utopias are unobtainable in practice, we preferred to base our comparisons on actually existing working environments. Another limitation of the study was that we only had access to information about patients who had consulted a psychiatric hospital. This means that those who were treated by their general practitioner only and those who did not seek any treatment at all were regarded as non-cases. Therefore, we should consider the possibility of referral bias. Soll-Johanning et al (34) investigated referrals to somatic hospital treatment and found some bias among employees at hospitals and general practitioners. Presumably due to easier access to hospital treatment, hospital staff had a higher probability of being treated at a hospital compared to others with the same health condition. Presumably due to a better access to non-hospital treatment, staff at general practitioners' offices had a lower probability of being treated at a hospital compared to others with the same health condition. No bias was detected among the rest of the 57 industries. To our knowledge, industrial referral bias for psychiatric disorders has never been investigated.

One has to be aware that only a fraction of people with depression are in contact with the hospital system. A study by Olsen et al (43) showed that the majority of people fulfilling diagnostic criteria for major depression in Denmark are not treated at all.

Work-related excess fractions for other diseases

To put the results of our study into perspective, we compared the estimated work-related excess fractions for mood disorders with those previously obtained for other types of disease using the exact same method. Feveile et al (40) estimated the excess fractions for neoplasm to be 0.066 for females and 0.128 for males; for varicose veins, they estimated it to be 0.477 for females and 0.545 for males. Kines et al (44) estimated excess fractions for injuries in various body parts among women to be 0.142 for the lower extremities, 0.164 for the head and neck, 0.195 for the thorax region, 0.235 for the back, and 0.274 for the upper extremities. The excess fraction

for disability retirement has been estimated to be 0.495 for females and 0.517 for males (45). LaMontagne et al (14), who estimated the excess fractions for depression related to job strain to be 0.172 among women and 0.132 among men, pointed out that job strain only represents one of several work-related factors. They argued that the impact of all working conditions on depression was actually higher than the estimates which they presented. Since the method used in the present study reflected the combined effect of all work-related factors, their argument was confirmed.

Our findings implied that a large proportion of mood disorders among working people can be regarded as work-related. Hence, the workplace is an important arena for primary interventions.

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